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Integrated nutrient management for sustainable onion production

Thangasamy, A.* and K.E. Lawande**

ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune 410505, Maharashtra

ABSTRACT

Present investigation was carried out to standardize integrated nutrient management for onion production. Results showed that integrated use of 75% recommended fertilizers along with organic manures and bio-fertilizers produced bulb yield at par with the previous recommendation (150:50:80:50 kg NPKS + 20 t FYM/ha) and improved soil organic carbon. Besides yield, integrated use of fertilizer, manures and biofertilizers increased TSS and total phenols content and decreased pyruvic acid as compared to inorganic fertilizer application alone. Combined application of fertilizers, organic manures and bio-fertilizers maintained initial soil available NPKS status. We conclude that the combined application of inorganic fertilizer (110:40:60:40 kg NPKS/ha) along with organic manures and biofertilizers produced yield at par with previous recommendation, improved bulb quality and maintained soil fertility. Adoption of this practice saved 25% inorganic fertilizers and protect environment from pollution.

Key words: Nutrient uptake, pyruvic acid, total phenols, storage loss, soil organic carbon.

INTRODUCTION

Onion production in India in the past increased with use of inorganic fertilizers, agrochemicals and by bringing non-traditional areas under onion cultivation (DOGR, 2). Onion production per unit area in India (16.41 t ha^{-1}) is well below the world average of 20.61 t ha^{-1} (FAOSTAT, 5). Productivity needs to be increased with available natural resources by growing improved cultivars and increased nutrient use efficiency rather than applying more agricultural inputs such as inorganic fertilizers (Tilman *et al*., 16; Zhang *et al*., 18) because intensive uses of chemical fertilizers and agrochemicals have caused several undesirable environmental consequences. Continuous use of inorganic fertilizers alone depleted soil micronutrients and decreased soil organic matter content. Depletion of soil micronutrients resulted in deficiency of micronutrients, while the reduction of soil organic matter affected the water holding capacity, soil structure, water infiltration and increased soil compaction (Dutta *et al*., 4). Soil organic matter is a key component as it influences soil biological, physical and chemical properties that define soil quality (Doran and Parkin, 3) and acts as a reservoir of plant nutrients and serves as a substrate for soil microorganisms (Dutta *et al*., 4). Addition of organic manures is essential for restoring soil quality and sustaining onion production in tropical countries. However, application of organic manures alone improves soil health, whereas, the bulb yield in organic systems was reduced by 22-45% over inorganic system (Lawande *et al*., 8). Therefore, nutrient management practices involving chemical fertilizers, organic manures and biofertilizers are essential for increasing the bulb yield and for maintaining soil health. Current recommendations indicated that the farmers are applying inorganic fertilizers and organic manures in excess of the crop requirement. Onion crops required about 90-95 kg N, 30-35 kg P_2O_5, 50-55 kg K_2O for producing 40-45 t bulbs per hectare (AINRPOG, 1). This indicated that we need to modify the current fertilizer recommendation of onion. Keeping this in view, we carried out a field experiment to evaluate eight integrated nutrient management modules for onion involving three organic manures, chemical fertilizers and bio-fertilizers.

MATERIALS AND METHODS

A field experiment was carried out to evaluate integrated nutrient management modules for onion for three years under All Indian Network Research Programme on Onion and Garlic from 2009-10 to 2011-12 during *rabi* season with onion cv. N-2-4-1 at ICAR-Directorate of Onion and Garlic Research, Pune, Maharashtra. The experiment consisted of nine treatments laid out in randomized block design with 3 replications (Table 1). Nitrogen, phosphorus, potassium and sulphur were applied as per treatments. Recommended dose of fertilizer for *rabi* onion was 150:50:80:50 kg NPKS/ha. Half of nitrogen, whole of P, K and S and biofertilizers were applied at the time of transplanting during the December. Organic manures, namely, farmyard manure, vermicompost

*Corresponding author's E-mail: astsamy@yahoo.co.in

**Former Vice Chancellor, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli

Table 1. INM treatment details.

No.	Treatment detail
T1	100% of recommended NPKS alone
T2	100% RDF + 20 t FYM/ha
T3	75% RDF + 15 t FYM/ha
T4	75% RDF + 7.5 t PM/ha
T5	75% RDF + 7.5 t VC/ha
T6	75% RDF + 7.5 t FYM + 3.75 t PM/ha
T7	75% RDF + 7.5 t FYM + 3.75 t VC/ha
T8	75% RDF + 3.75 t PM + 3.75 t VC/ha
T9	75% RDF + 5 t FYM + 2.5 t PM + 2.5 t VC/ha

RDF = Recommended dose of fertilizers, FYM = farm yard manure, PM = Poultry manure, VC = Vermicompost
Azospirillum and phosphorus solubilizing bacteria @ 5 kg/ha each to all treatments

and poultry manure were applied as per treatment at transplanting and mixed thoroughly in 15 cm top soil layer. The farmyard manure, poultry manure and vermicompost contained 0.99, 2.40 and 1.21% N, 0.32, 0.40 and 0.31% P, 0.88, 2.09 and 0.57% K and 0.32, 0.39, 0.11% S, respectively. Remaining nitrogen was applied in two equal split doses, at 30 and 45 days after transplanting. Standard package of practices were followed to grow onion crop. Crop was harvested after attaining maturity during last week of April. Bulbs were covered by its top and left in the field for curing for 3-4 days. After neck cutting, the bulb yield was recorded.

Representative plant samples (twenty plants) were collected for the biochemical and nutritional analysis. Chopped samples were dried in oven at 60ºC till the constant weight was attained. The samples were ground and passed through 2 mm sieve and used for nutrient analysis. The plant samples were digested using diacid digestion method and analyzed for phosphorus by vanadomolybdate method, potassium by flame photometry, sulphur by turbidimetric method and Zn by atomic absorption spectrophotometer. Total N was determined by Kjeldahl's digestion method. The nutrient analysis of plant samples were carried out in accordance with the methods reported by Page (11). The nutrient uptake was calculated by multiplying nutrient concentration with dry matter yield. Soil samples from 0-15 cm were collected randomly using auger after harvest for soil analysis. Soil samples were analysed as per the standard procedures.

Fresh onion bulbs were used for determining total soluble soilds (TSS), pyruvic acid and total phenols content in bulbs. TSS of onion bulbs estimated using hand refractometer. Pyruvic acid content was estimated using dinitro phenyl hydrazine (DNPH) reagent method (Schwimmer and Weston, 13) and total phenolics content was estimated spectrophotometrically using Folin-Ciocalteau reagent (using gallic acid as a standard). Amount of total phenolics was expressed as mg gallic acid equivalents (GAE)/kg fresh onion.

Onion bulbs from each treatment were stored in perforated plastic crates under top and bottom ventilated storage structure under ambient conditions in replication. Total storage losses were recorded at 30 days interval up to 150 days from the date of harvest. Total storage losses were estimated and expressed in per cent. Total number of rotten and spouted bulbs was noted down at 30 days interval up to 150 days.

Three years data (2009-10 to 2011-12) was pooled and analysed statistically using Statistical Analytical System (SAS) software version 9.3.

RESULTS AND DISCUSSION

Combined application of 75% RDF along with organic manures recorded bulb yield at par with 100% RDF + 20 t/ha (Table 2). Among the treatments, combined application of 75% RDF + 5.0 t FYM + 2.5 t PM + 2.5 t VC/ha (T9-44.0 t/ha) recorded higher marketable bulb yield followed by 100% RDF + 20 t FYM/ha (T2-43.9 t/ha) and 75% RDF + 7.5 t FYM + 3.75 t PM/ha (T6-43.7 t/ha). Integrated application of 75% NPK, 10 t FYM ha^{-1} and *Azotobacter* to onion crop produced bulb yield at par with 100% RDF at Bichpuri, Uttar Pradesh (Singh and Pandey, 14). Among the INM treatments, application of 75% RDF along with combination of two or three organic manures (T6, T7, T8 and T9) produced higher bulb yield over single organic manure with 75% RDF (T3,

Table 2. Initial soil properties of experimental field.

Parameter	Value of type
Soil texture	Clay loam
pH	7.89
EC (dS/m)	0.18
SOC (mg/kg)	6.8
Available N (kg/ha)	207.7
Available P (kg/ha)	30.7
Available K (kg/ha)	569.0
Available S (kg/ha)	16.1
Available Fe (mg/kg)	3.93
Available Zn (mg/kg)	0.45
Available Mn (mg/kg)	2.92
Available Cu (mg/kg)	2.09

T4 and T5). Improvement in bulb yield with integrated use of organic manures and inorganic fertilizers might be due to control release of nutrients in the soil through mineralization of organic manures, which might have facilitated better crop growth (Mitra *et al*., 10). This indicated that application of inorganic fertilizers can be reduced by 25% with integrated use of inorganic fertilizer and organic manures without reducing the bulb yield. No significant difference was observed between the treatments for bulb size, bolter and doubles.

Nitrogen uptake in inorganic fertilizer applied treatment (T1) was significantly lower (97.9 kg/ha) than integrated use of organic manure and inorganic fertilizers (Table 2). However, no significant difference was observed between the treatments for nitrogen uptake. Integrated use of organic and inorganic sources of plant nutrients increased P, K, S and Zn uptake over inorganic fertilizer application (T1). Highest P and S uptake was recorded with combined application of 75% RDF + 5.0 t FYM + 2.5 t PM + 2.5 t VC/ha, whereas, maximum K uptake was registered with application of 75% RDF along with 7.5 t FYM and 3.75 t PM/ha. The higher nutrient uptake with application of inorganic fertilizers and organic manures could be due to addition of plant nutrients directly through organic manures and indirectly through solubilization of unavailable native nutrients and chelation of complex intermediate organic molecules produced during decomposition of added manures (Mitra *et al*., 10).

Highest pyruvic acid content was recorded with application of 100% RDF (T1-3.0 μmoles/g fresh onion) followed by 100% RDF + 20 t FYM/ha (T2-2.9 μmoles/g fresh onion) and 75% RDF + 7.5 t PM/ha (T4-2.8 μmoles/g fresh onion) (Fig. 1). The increase in pyruvic acid content in onion bulbs in these treatments were due to higher application of readily available inorganic sulphur. The lowest pyruvic acid content was recorded with application of 75% RDF along with FYM or VC. This lower pyruvic acid in this treatment could be due to low sulphur supply from these organic sources and reduced application of inorganic sulphur (40 kg/ha) as against 50 kg/ha in 100% RDF. Previous studies have also showed that increasing the sulphur level increased the pyruvic acid content of onion bulbs (Qureshi and Lawande, 12; Thangasamy *et al*., 15). Integrated application of inorganic and organic fertilizer significantly increased the total soluble solids over inorganic fertilizer treatments and the TSS in INM treatments ranged from 12.7 to 13.0°Brix (Table 2). The highest TSS was observed with application of 75% RDF along with 5.0 t FYM, 2.5 t PM and 2.5 t VC/ha. Lee *et al*. (9) reported that application of organic manures recorded higher total soluble solids in onion as compared to inorganically produced onion bulbs. Similarly, increase in TSS with application of organic manure was observed by Yeptho *et al*. (17). Application of organic manure along with inorganic fertilizers registered significantly higher phenol content as compared to the application of inorganic fertilizer alone (TI-400 mg gallic acid equivalent (GAE)/kg fresh onion). The total phenols content in INM treatments varied from 530 to 650 mg GAE/kg fresh onion (Fig. 2).

Lowest total storage losses were recorded with application of inorganic fertilizers (23.4%) followed by application of 75% RDF along with 7.5 t FYM and 3.75 t VC/ha (Fig. 3). Whereas, higher storage losses was noticed in plot received 75% RDF + 7.5 t VC/ha. The

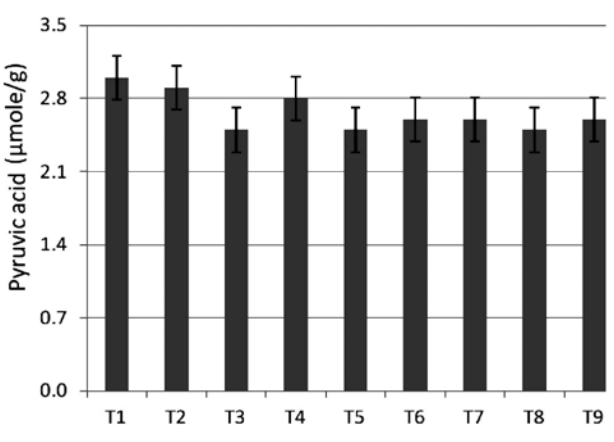

Fig. 1. Effect of combined application of organic manures and inorganic fertilizers on pyruvic acid (μmole/g fresh onion).

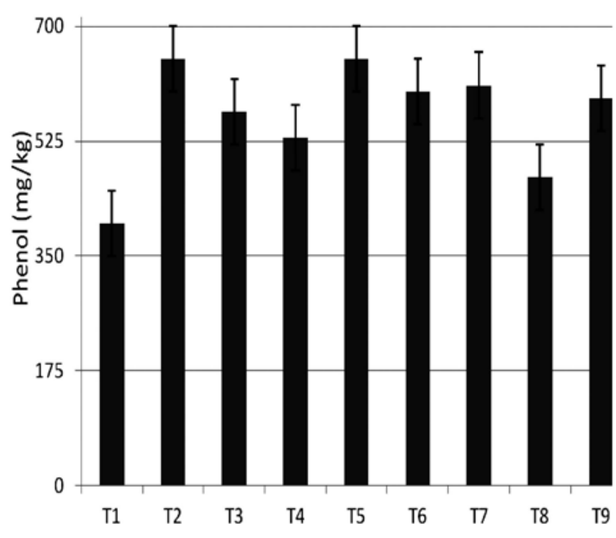

Fig. 2. Effect of integrated use of organic manures and inorganic fertilizers on total phenols content (mg GAE/kg fresh onion).

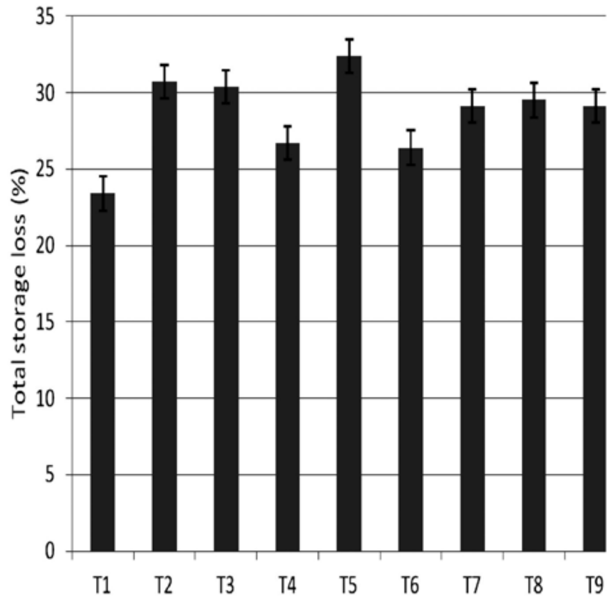

Fig. 3. Effect of integrated use of organic manures and inorganic fertilizers on total storage losses.

higher storage losses of onion bulbs with application of organic manure could be due to increased microbial population. The increased microbial load in the bulbs harvested from integrated nutrient management might have contributed to the rotting of onion bulbs. Number of rotten bulbs during storage was higher in organic manure applied treatments over inorganic treatments (Fig. 4). Rotting of the bulbs produced with combined application of organic manures and inorganic fertilizers started after 30 days, whereas rotting of bulbs harvested with addition of chemical fertilizers alone started after 60 days. No rotting was observed up to 60 days of storage in inorganically produced bulbs. Total number of rotten bulbs recorded in INM treatments varied from 27 to 42, whereas, in chemical fertilizers alone applied treatment, the total number of rotten bulbs after 150 days was 19, which is significantly less as compared to integrated use of organic manure and inorganic fertilizers. Application of good quality organic manures is essential for improving the quality of onion bulbs.

Application of organic manures along with inorganic fertilizers did not influence the soil pH after harvest. Soil available nutrients analysed after harvest did not vary significantly (Table 3). Soil organic carbon content after harvest in all the treatments was significantly higher than the initial values of 0.68%. Soil organic carbon varied between 7.7 to 8.8 mg/kg. Application of 75% RDF along with 7.5 t PM/ha recorded higher soil organic carbon followed by combined application of 75% RDF with 5.0 t FYM, 2.5 t PM and 2.5 t VC/ha (8.4 mg/kg). The increase in soil organic carbon after harvest was due to the addition of organic matter through root exudates, root biomass addition and supply of readily decomposable organic matter due to good crop growth (Goyal *et al.*, 6) and organic manures added to the soil before transplanting. The lowest soil organic carbon content was recorded in inorganic fertilizer alone applied treatment. However, the soil organic carbon increased over the initial value recorded before start of the experiment. The increase in soil organic carbon after the harvest in inorganic fertilizer

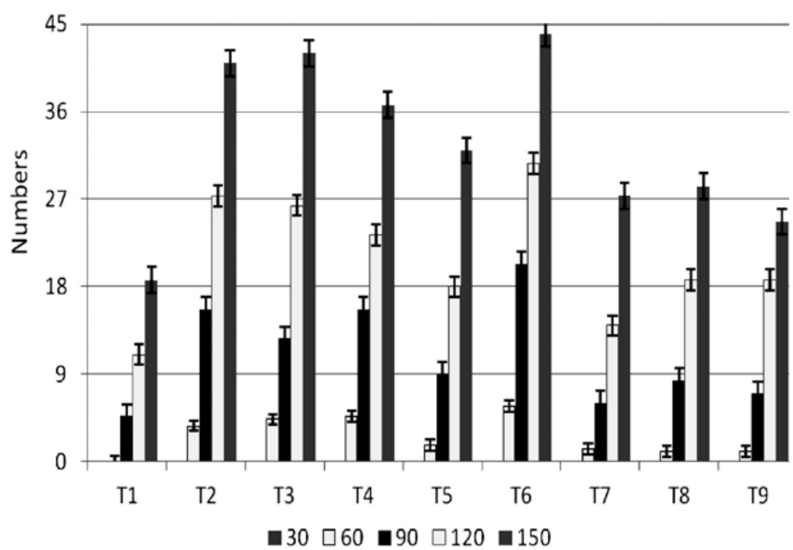

Fig. 4. Cumulative rotting losses of onion bulbs during storage at 30-day interval.

Table 3. Effect of integrated use of organic manures and inorganic fertilizers on onion yield and nutrient uptake.

Treatment	ABW (g)	MBY (t/ha)	D+B (%)	TBY (t/ha)	TSS (°Brix)	Plant nutrient uptake				
						N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Zn (g/ha)
T1	71.3	41.9	3.0	43.5	12.3	97.9	16.4	77.5	26.5	140.3
T2	71.6	43.9	3.0	45.4	12.8	102.1	17.3	78.1	27.7	150.7
T3	72.3	41.9	3.4	43.7	12.8	100.0	16.7	79.3	26.2	138.5
T4	70.9	42.3	2.5	43.5	12.7	100.4	16.4	79.1	28.1	146.2
T5	69.5	42.1	3.1	43.7	12.9	100.1	16.7	73.8	27.2	144.6
T6	73.2	43.7	3.2	45.5	12.7	107.0	17.3	79.5	28.4	144.4
T7	68.5	42.6	3.0	44.1	12.9	104.6	17.2	79.0	27.1	148.9
T8	70.6	43.4	3.2	45.0	12.9	100.5	17.2	78.2	28.5	150.1
T9	71.7	44.0	3.5	46.0	13.0	104.6	18.1	77.5	28.2	137.9
LSD (p = 0.05)	NS	NS	NS	NS	0.5	7.6	NS	6.0	NS	9.0
CV (%)	4.2	3.4	20.6	3.5	2.5	4.4	7.1	4.5	5.9	3.6

ABW = Av. Bulb weight, MBY = Marketable bulb yield, D + B = Twin bulbs + Bolters, TBY = Total bulb yield, TSS = Total soluble solids

applied plots was due to addition of root exudates and root biomass accumulation. The soil available N, P, K and S status showed that the soil N, P, K and S status after harvest was maintained in all the treatments (Table 4). Besides plant nutrient addition, application of organic manures conserve native soil nutrients, enhancing biological nitrogen fixation and soil biological activity (Javaria and Khan, 7).

Integrated use of 75% RDF (110:40:60:40 kg NPKS/ha) along with organic manures and biofertilizers produced marketable bulb yield statistically at par with previous recommendation (150:50:80:50 kg NPKS + 20 t FYM/ha) and inorganic fertilizer application alone. Application of inorganic fertilizer alone recorded the bulb yield at par with integrated nutrient management. However, the previous results showed that continuous application of inorganic fertilizer alone depleted secondary nutrients and micronutrients from soil native reserves. Application of inorganic fertilizers and organic manures increased the TSS and total phenols content but reduced pyruvic acid content. Combined application of organic manures and inorganic fertilizers improved soil organic carbon as compared to initial value recorded before transplanting and maintained initial soil available NPKS status. These results showed that combined application of inorganic fertilizer (110:40:60:40 kg NPKS/ha) along with organic manures and biofertilizers produced yield at par with previous recommendation, improved bulb quality and maintained soil fertility status. Adoption of this integrated nutrient management practices saves

Table 4. Effect of INM on soil available nutrient status (kg/ha) after harvest of crop.

Treatment	pH	SOC (mg/kg)	N	P	K	S
T1	8.16	7.7	159	25.0	512	10.0
T2	8.22	8.2	163	28.2	596	10.4
T3	8.19	8.0	160	26.8	567	8.5
T4	8.25	8.8	162	24.2	572	14.2
T5	8.27	7.9	164	27.2	548	12.1
T6	8.04	8.2	150	32.5	616	11.6
T7	7.85	8.1	154	27.8	613	17.7
T8	8.15	7.8	159	29.9	608	13.3
T9	8.17	8.4	155	29.4	579	13.1
LSD (p = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	2.67	7.15	5	23.5	12	67.1

SOC = Soil organic carbon

inorganic fertilizers by 25% and protect environment from chemical pollution.

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